Organic farming practices favor bacterivore and fungivore nematodes as compared to plant-parasitic nematodes

S.S. Briar[1,2], P.S. Grewal[1,2], Deborah H. Stinner[1], and S.A. Miller[2]
[1]Dept. of Entomology & [2]Dept. of Plant Pathology,
The Ohio State University, OARDC, Wooster, OH 44691-4096, USA

Abstract

A primary objective of nematological research is to identify farming strategies that increase multiplication of free-living nematodes that contribute to nutrient cycling but reduce that of plant parasitic nematodes that reduces crop yield. We hypothesized that the organic farming system would be dominated by bacterial and fungal feeding nematodes but not by plant parasitic nematodes. Therefore, we compared nematode communities for a four-year period (2000-2003) in a field transitioning to organic farming with that under low tillage conventional management. Conventional plots had corn and soybean rotation and received synthetic inputs. Organic plots had corn, soybeans, oats and hay rotation and received beef and poultry manure. Organic farming favored the population of bacterivore, fungivore, omnivore and predatory nematodes over the 4 years as compared to conventional farming system. Nematode structure, maturity, diversity, richness, basal, enrichment, and channel indices showed no significant differences among the farming systems. However combined maturity index (based on both free living and plant parasitic nematodes) was higher in conventional farming as compared to organic farming system. The conventional farming system had significantly higher populations of total plant parasitic and the root lesion nematode *Pratylenchus crenatus*, compared to the organic farming system during most of the study period. Nematode faunal profile based on enrichment and structure indices revealed that the food webs were highly enriched and moderately to highly structured, and the decomposition channels were predominantly bacterial in both the farming systems.

Introduction

- Nematode communities play a significant role in a nutrient cycling in the ecosystem.
- Various nematode indices such as maturity, structure and diversity indices are considered as indicators of ecosystem health.
- Nematode faunal profile (Plate 1) which provides a framework of the soil food web can be used as a diagnostic tool to measure the health of soil in agro-ecosystems (Ferris et al., 2001).

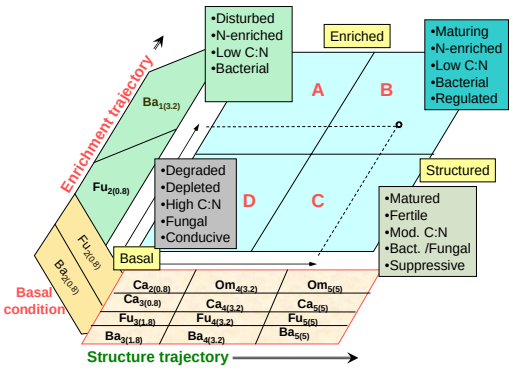

Plate 1. Conceptual Model relating nematode community to soil food web health. Bax, Fux, Cax, Omx (x=1-5): functional guilds of nematodes that are bacterivores (Ba), fungivores (Fu), carnivores (Ca) and omnivores (Om) where the guilds have the character indicated by x on the cp scale (Ferris et al., 2001).

Hypothesis

- Organic farming system would be dominated by beneficial bacterivore and fungivore nematodes but not plant parasitic nematodes.

Objectives

- Determine the long-term effects of organic farming and low tilled conventional farming systems on soil nematode community.
- Compare population of free-living and plant parasitic nematodes between the two farming systems.

Methods

Experimental design: Split block design (Plate 2) Plot size 60'x50'
Treatments: Organic and conventional farming systems
Conventional Farming system (1):
- Rotation: Corn-Soybeans
- Application : Synthetic fertilizers and insecticides
- Tillage: Every alternate year

Organic farming system (2):
- Rotation: Corn-Oats-Soybeans-Hay
- Application: 12 T/A raw straw pack beef manure + 1.25 T/A Day-Lay poultry compost in corn and 8 T/A raw straw pack manure + 0.8 T/A DayLay poultry compost in oats
- Tillage: Twice a year

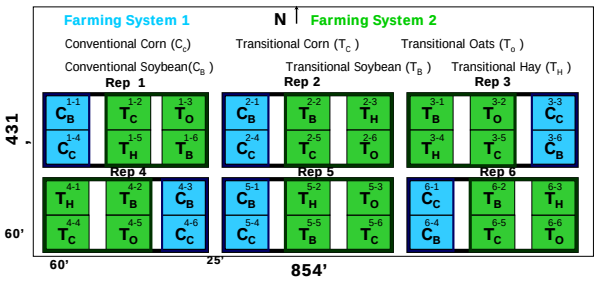

Plate 2. Layout map of field crops organic transition experiment.

Sampling: Three soil cores (2 cm dia. X 15 cm depth) were collected from each plot in spring & fall from year 2000-2003.

Nematode extraction: Nematodes were extracted from 10-g sub sample of soil using Bearmann funnel technique.

Nematode Identification and counting: All nematodes were identified to genus level and assigned to a trophic group: plant parasitic, fungivore, bacterivore, carnivore and omnivore according to Yeates *et al* (1993). Colonizer persister value (c-p value) were also assigned to each genus according to Bongers (1990).

Nematode indices: Nematode abundance, enrichment, structure, maturity and species diversity indices were calculated using standard formulae (Ferris et al., 2001;Yeates et al., 1993).

Statistical analysis: Repeated measures analysis of variance (PROC GLM, SAS Ver. 9) was used to obtain F-values for the split block experimental design using the appropriate error terms in the model, to compare between the farming systems over the years.

Results and Discussion

- Population of bacterivore ($P < 0.01$) (Fig. 1A) and fungivore nematodes ($P < 0.1$) (Fig. 1B) over the 4 years was significantly higher in the organic as compared with the conventional farming system (Fig. 1 and 2).
- Abundance of plant parasitic nematodes (*P=0.03*) (Fig. 1E) and migratory endoparasitic *Pratylenchus crenatus* (*P=0.01*) (Fig. 1F) was significantly lower in organic than conventional farming system.
- Nematode maturity, diversity and richness indices showed no significant differences among the farming systems (Fig. 1). However combined maturity index (based on both free living and plant parasitic nematodes) was higher in conventional farming as compared to organic farming system (*P=0.01*) (Fig. 2A).
- Nematode faunal analysis revealed that the food webs were highly enriched and moderately to highly structured in both farming systems (Fig. 3). Also decomposition channels in both systems were bacterial driven.
- Proportion of free-living nematodes was negatively correlated (*r=-0.60, P=0.0001*) with abundance of plant parasitic nematodes (Fig. 4).

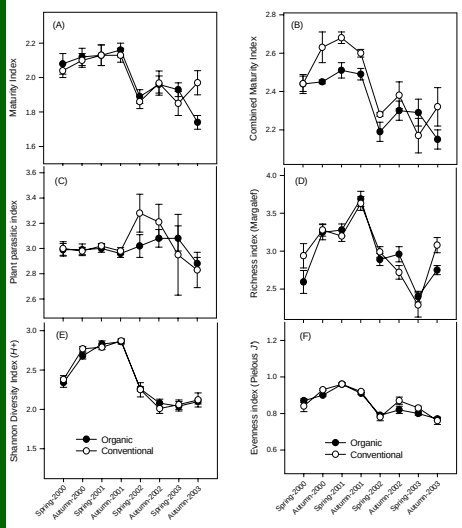

Figure 2: Comparison of nematode community indices between organic and conventional farming system from spring 2000 to autumn 2003. A) Maturity; B) Combined maturity; C) Plant parasitic; D) Richness Index ; E) Shannon diversity (*H'*) and F) Evenness indices.

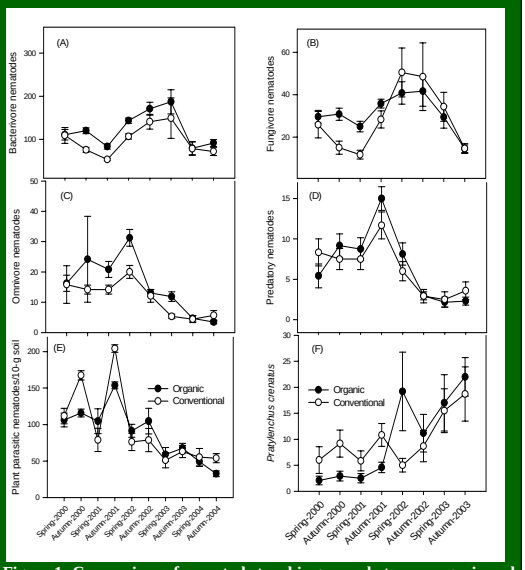

Figure 1: Comparison of nematode trophic groups between organic and conventional farming system from spring 2000 to autumn 2003. A) Bacterivores; B) Fungivores; C) Omnivores; D) Predatory; E) Total plant-parasitic and F) *Pratylenchus crenatus* (Root lesion nematode).

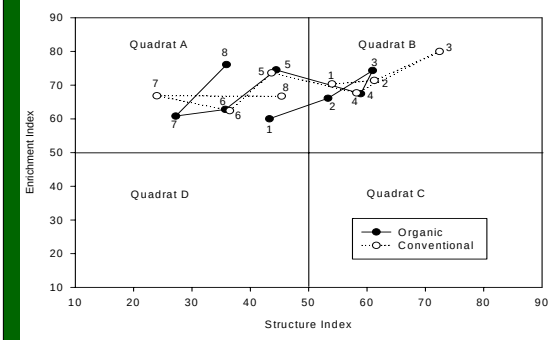

Fig. 3: Comparison and temporal progression of food web indicated by nematode faunal analysis in organic and conventional farming systems.. Numbers 1-8 represent the progression of changes in the fauna in each farming system from spring 2000 to autumn 2003.

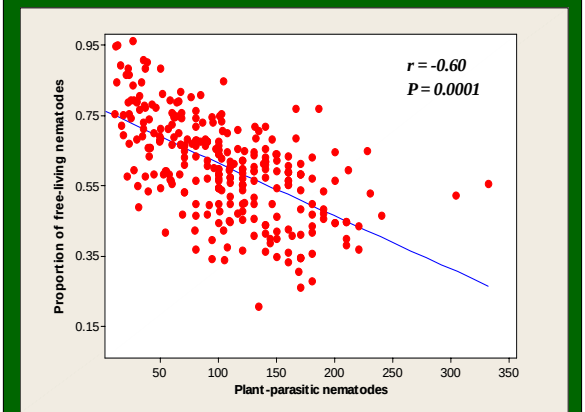

Fig. 4: Correlation between proportion of free-living nematodes and plant parasitic nematodes.

Conclusions

- There were significantly more bacterivore and fungivore nematodes in the organic farming than the conventional farming system.
- Farming systems did not differ significantly in diversity, richness and evenness of nematode community.
- Organic farming showed a significant reduction in total plant parasitic nematodes and migratory endoparasite *Pratylenchus crenatus* populations as compared to conventional farming system.
- The food webs were highly enriched and moderately to highly structured and the decomposition channels were bacterial driven in both the farming systems.
- Abundance of plant parasitic nematodes showed a negative correlation with abundance of free-living nematodes suggesting competitive exclusion.

Acknowledgements

We thank Dr. Ganpat Jagdale for help with nematode identification and suggestions.

References

Bongers, T. 1990. The maturity index: an ecological measure of environmental disturbance based on nematode species composition. Ocelogica,. 83:14-19.

Ferris, H., Bongers, T., and Goede, R.G.M. de. 2001. A framework for soil web diagnostics: extension of the nematode faunal analysis concept. Applied Soil Ecology. 18: 13-29.

Nahar, M. S., Grewal, P. S., Miller, S. A., Stinner, D., Stinner, B. R., Kleinhenz, M. D., Wszelaki, A., and Doohan, D. 2005. Differential effects of raw and composted manure on nematode community, and its indicative value for soil microbial, physical and chemical properties. App. Soil Ecol. (In press).

Yeates, G W., Bongers, T., De Goede, R.G.M., Freckman, D.W., and Georgieva, S.S. 1993. Feeding-habits in soil nematode families and genera – an outline for soil ecologists. Journals of Nematology. 25: 315-331.